Original Article

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| The Role of Doppler Ultrasound in High Risk Pregnancy  |

**Saba Khan1, Farheen Amir2, Geeta3, Erum Majid Shaikh4, Marukh Fayaz5, Khadija Bano6**

1Assistant Professor, 4Associate Professor, 5Medical officer, 6Professor

1,4,5,6 Department of Obstetrics and Gynaecology, Jinnah Postgraduate Medical Centre, Karachi

2,3Tibri hospital, Karachi

Correspondence: Dr Erum Majid Shaikh

Assistant Professor, Dept of Obs and Gynae,

Jinnah Postgraduate Medical Centre, Karachi

erum.laghari@hotmail.com

Abstract

Objectives:  To estimate the frequency of Doppler velocimetry in women with high-risk pregnancy and to analyze the outcomes in patients with and without Doppler velocimetry resulting in the management of high-risk pregnancy.

Methodology: A descriptive case-series study was conducted in department of Gynecology and Obstetrics of Jinnah Post-graduate Medical Centre, Karachi, from August to 18 February 2019.  A total of 135 pregnant  females,  who  were  admitted   through OPD and  ER of Department of Obstetrics & Gynecology, ward-9 at Jinnah Postgraduate Medical Centre, Karachi were selected  included  in  the  study as per  inclusion criteria. Informed consent was signed by guardian or the patient by herself. The participant’s detailed history were elicited and thus to compare the outcomes in patients with and without Doppler velocimetry. Blood sample were taken from every patient for base line test like complete blood count, electrolytes, blood sugar level, blood urea, serum creatinine and others for each patient. All data information was noted on Performa.

Results:Overall 135 high risk pregnant women were participated in current study and were allocated into two groups; Group A 54(40%) women who underwent Doppler velocimetry and Group B or control group 81(60%) women without Doppler velocimetry. A comparison of the outcomes in patients with or without Doppler velocimetry in high risk pregnant women showed as; C section was performed in 35(64.8%) vs. 63(77.8%) (P=0.098) cases, pre-term deliveries were found in 16(29.6%) vs 38(46.9%) (P=0.045) cases, and abnormal amniotic fluid was seen in 25(46.3%) vs 28(34.6%) (P=0.172) cases with and without Doppler velocimetry results, respectively.

Conclusion: There was a significant role of Doppler studies in the management of high-risk pregnancies and perinatal as well as neonatal outcome but for each institution, the role of Doppler studies in late pregnancy is being influenced by the usage of other tests of fetal wellbeing which are already well established in clinical practice.

Keywords: Doppler ultrasound, high-risk pregnancies, pre-eclampsia.

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Introduction

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| Authorship Contribution:  1,2Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work, 3Active participation in active methodology, 4Drafting the work or revising it critically for important intellectual content, participated in the acquisition and data analysis, 6Final approval of the version to be published, |
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Worldwide, both pre-eclampsia and eclampsia are considered as leading causes of deaths in mother and children, especially in developing countries.1 About 50,000 maternal deaths are reported each year due to eclampsia, and majority of them occurs in developing countries. In Pakistan, about 34% of maternal deaths occur due to eclampsia in health care facilities .2]Pre-eclampsia (Multi-systemic disorder) commonly occurs after 20 weeks of pregnancy, resulting in high risk pregnancy. It has been reported that the prevalence of pre-eclampsia worldwide ranges from 3-8% of pregnancies, and about 8.5 million cases are reported annually.3 A  study conducted in United Kingdom showed that 4-6% of pregnancies were complicated due to Pre-eclampsia.4 Pre-eclampsia being the third leading cause of maternal morbidity and mortality worldwide.5  The World Health Organization (WHO) reports that about 60,000 women die each year from pre-eclampsia worldwide and it causes 11% of deaths in the UK and 24% of all maternal deaths in India.6,7 In the early pregnancies, there is about 4.1% risk of preeclampsia, moreover, it is also indication of pre-eclampsia in subsequent pregnancies.8

The Doppler flow velocity waveform is performed within the fetal blood circulation in the umbilical cord. Such fluid flow waves (FVW) from fetal-placental circulation depend on the fetal heart rate, blood pressure, peripheral vascular resistance or downstream.9 Different types of measurements have been mentioned in the literature to measure Doppler signals specifically and productively.10 Indicators can be calculated as the ratio between high systolic speed (A), high diastolic peak speed (B) and moderate speed. Mostly in clinical practice we use pulsatility index (PI = (A - B) / description) and the resistance index (RI = (A - B) / A).11 A study was conducted during third trimester by using standard Doppler waveforms that reported positive effects on pregnancy. However, minor impact on obstetric management were observed.12 The initiation of Doppler studies helped to investigate and identifying significant risks. Furthermore, this is also essential for establishing policy and goals including; prioritizing interventions, allocation of resources, identification of high-risk pregnant women to be monitored and cared for, as well as the development of risk management.

Methodology

This descriptive case-series study was carried out at the department of Gynecology and Obstetrics of tertiary-care hospital, Jinnah Post-graduate Medical Center, Karachi, from 18 August to 18 February 2019 after receiving approval from the Ethical review board of JPMC (IRB No F-2-81/2022-GENL/125/ JPMC). Participants were randomly assigned to follow-up samples. For women with active singleton pregnancy and frequent antenatal visits and gestation age ≥ 20 weeks, normal BP measured at enrollment as per patient record, ages 17-34 years included. Patients with high blood pressure, proteinuria, or any other kidney disease, with unsure dates, as per history, history of multiple pregnancies, any maternal heart disease at enrollment were excluded. The sample size of 135 was estimated using the WHO calculator, a fraction of 22% Poly / oligohydramnios without Doppler velocimetry12 was taken as a reference to 95% confidence interval and 7% error gene. Participants were recruited from the OPD and ER of the Gynecology and Obstetrics department of JPMC, Karachi after a positive and negative explanation of the study. A consent form is requested from the caregiver or the patient herself. A detailed participant history was proposed regarding high blood pressure, proteinuria, weight, and gestational age, and thus the frequency of high-risk pregnancy was determined and thus compared outcomes in patients with Doppler velocimetry and externally. Participants were assigned into two different groups’ i.e. group ‘A’ with ultrasound Doppler and group B without ultrasound Doppler. The participants of Group ‘A’ received waveform studies during the first visit followed by tests further followed by Doppler studies. A continuous system was used while performing Doppler flow velocity. The participants lied face up and tilted sideways, placed a wedge under one hip. The waves found in the umbilical artery and a maternal utero-placental were used to calculate the ratio of peak systolic (S) to very low diastolic (D) Doppler shift frequency. In case of regular periods the last menstrual period was asked to calculate the gestational ages of participants. Blood samples were taken from each patient to check first line such as total blood count, electrolytes, blood sugar level, blood urea, serum creatinine, and so on in each patient. All data is marked on Performa (attached) by the researcher. Data was analyzed by using version SPSS 16 and variables such as age, gestational age, BMI were summarized on average and normal while diabetes mellitus, anemia, obesity and side effects (birth methods, premature delivery, abnormalities (poly/oligohydramnios) (amniotic fluid) were reported in quantities and percentages. A non-parametric chi-square tests were used to compare results and feature variability between Doppler velocimetry and outside. Impact adjustments such as age, gestational age, diabetes, anemia, obesity, were controlled separately. Post stratification A Chi-square test was used to determine the effect of this on the results.  P ≤ 0.05 was considered.

Results

A total of 135 high-risk pregnant women were incorporated into the study. The median age was 30.5 ± 4.8, gestational age was 35.6 ± 4.6 weeks and BMI was 27.1 ± 3.9 kg / m2. (Table I)

Distribution of qualitative variables including doppler velocimetry with and without including variables such as age, gestational age, BMI, anaemia, Obesity, Diabetes Mellitus frequency and percentages were mentioned in Table II.

While comparing the outcome in patients with Doppler velocimetry and without Doppler velocimetry with study variables are mentioned in table III. Patients who underwent Doppler velocimetry with fetal outcome of good Apgar were 37(68.5%) and poor Apgar were 17(31.8%) and patients without Doppler Velocimetry with Good Apgar were 32(39.5%) and with poor Apgar were 49(60.4%).

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| **Table I: Descriptive statistics of study subjects.** |
| **Study Variables** | **With Doppler velocimetry** | **Without Doppler velocimetry** | **Total** |
| Age (years) | 30.2±-4.5 | 31.9±4.7 | 30.5±4.8 |
| Gestational age at presentation (in week) | 24.6±3.5 | 27.8±4.6 | 26.8±5.1 |
| Gestational age | 36.2±3.9 | 37.5±4.1 | 35.6±4.6 |
| BMI | 28.1±3.21 | 27.4±3.54 | 27.1±3.9 |

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| **Table II: Distribution of qualitative variables.** |
| **Study variables** | **N (%)** |
| **Doppler velocimetry**WithWithout | 54(40%)81(60%) |
| **C/section** | 98 (72.6%) |
| **Pre-term delivery** | 54 (40%) |
| **Abnormal AF** | 53 (39.3%) |
| **Anemia** | 56(41.5%) |
| **Obesity** | 69 (51.1%) |
| **Diabetes Mellitus** | 59 (43.7%) |

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| **Table III: Comparison of outcomes in patients with and without Doppler velocimetry in high-risk pregnancy.** |
| **Outcomes** | **Doppler velocimetry** | **Total** | **P-Value** |
|  | With | Without |
| **C/Section** | No | 19(35.2%) | 18(22.2%) | 37(27.4%) | 0.098 |
| Yes | 35(64.8%) | 63(77.8%) | 98(72.6%) |
| **Pre-Term Delivery** | No | 38(70.4%) | 43(53.1%) | 81(60%) | 0.045 |
| Yes | 16(29.6%) | 38(46.9%) | 54(40%) |
| **Abnormal AF** | No | 29(53.7%) | 53(56.4%) | 82(60.7%) | 0.172 |
| Yes | 25(46.3%) | 28(34.6%) | 53(39.3%) |

Comparison between doppler and non-doppler with stratification between different independent variables were described in table IV. Outcome planning with and without Doppler velocimetry causes high-risk pregnant women to act on age, anemia, obesity, and diabetes. Comparisons were made using chi-square tests. P-value was kept at <0.05 as important.

Discussion

The findings suggested that Doppler velocimetry in umbilical cord was a good indicator to detect adverse pregnancy outcome, compared with ultrasound for fetal well-being. Authors from previous studies have never considered the age factor of pregnancy.13

In the current study, changes in UAPI allowed for higher risk predictors (approximately three times) of four out of five indicators of reproductive with inauspicious effects were studied. In cases of respiratory distress syndrome the risk was 50% higher but not statistically significant. In contrast, MCAPI mutations allow for greater risk predictions only to SGA, and changes in UAPI / MCAPI ratings allow for SGA and HIS predictions only.

In several studies of more than one vessel contributed to improved fetal status, as Doppler velocimetry was able to predict the reproductive outcomes, in fetuses with validated IURG diagnosis.14, 15, 16 In the present study, pregnant women with high blood pressure were included, as it could lead to the death of the placenta which could present a risk of fetal injury, without actual presence.

The critical changes in the Doppler velocimetric pattern like zero diastole or distorted flow provided relevant information in the evaluation of adverse birth outcome.13, 17 The present study not only looked over the missing or deferred diastole changes in the umbilical cord, but also observed changes where pulsatility indicators were more than 95th percentile.

There were 75% of cases who had a three-day interval between Doppler studies and work in the current study whereas Baschat et al18 conducted a study with 50% cases had one day interval. In this study the median interval between the last Doppler study and delivery was not calculated whereas, in some studies the median interval was > 7 days.12, 19 Variation in the delivery time of the Doppler study may explain the difference in results, given that severe changes in the Doppler pattern of the umbilical artery and cerebral artery preceded the deterioration of fetal status18 by 10–14 days.

Birth before maturation remains one of the most important cause of child morbidity and mortality [12, 18]. In the literature, some authors analyzed newborn infants only, especially those under 32 weeks of age, in contrast with the cases in the current study, in which different pregnancy groups were included, allowing for a different analysis of outcomes in newborns and examined the effect of premature birth on maternal outcomes.18, 19, 20

There were significant outcomes with respective to gestational age after adjustment. It is well-established that in the incidents of placental abruption and

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| **Table IV: Comparison between Doppler and non-doppler with stratification between different independent variables.** |
|  |  | **Doppler Velocimetry (positive)** | **Doppler Velocimetry (negative)** | **P- value** |
| **Anemia**No | **C/Section**YesNo | 23(67.6%)11(32.4%) | 39(86.7%)6(13.3%) | 0.6180.042 |
| Yes | YesNo | 12(60%)8(40%) | 24(66.7%)12(33.3%) |
| **Obesity**No | **C/Section**YesNo | 14(58.3%)10(41.7%) | 30(71.4%)12(28.6%) | 0.1450.278 |
| Yes | YesNo | 21(70%)9(30%) | 33(84.6%)6(15.4%) |
| **DM**No | **C/Section**YesNo | 22(62.9%)13(37.1%) | 29(70.7%)12(29.3%) | 0.1390.466 |
| Yes | YesNo | 13(68.4%)6(31.6%) | 34(85%)6(15% |
| **Age**<25 years | **C/Section**YesNo | 16(64%)09(36%) | 34(72.3%)13(27.7%) | 0.456 |
| >25 years | YesNo | 19(65.5%)10(34.5%) | 29(85.3%)05(14.7%) | 0.098 |
| **Anemia**No | **Pre-term delivery**YesNo | 11(32.4%)23(67.6%) | 24(53.3%)21(46.7%) | 0.2930.063 |
| Yes | YesNo | 02(25%)15(75%) | 14(38.9%)22(61.1%) |
| **Obesity**No | **Pre-term delivery**YesNo | 07(29.2%)17(70.8%) | 17(40.5%)25(59.5%) | 0.0480.358 |
| Yes | YesNo | 09(30%)21(70%) | 21(53.8%)18(46.2%) |
| **DM**No | **Pre-term delivery**YesNo | 9(25.7%)26(74.3%) | 20(48.8%)21(51.2%) | 0.5540.039 |
| Yes | YesNo | 7(36.8%)12(63.2%) | 18(45%)22(55%) |
| **Age**<25 years | Pre-term deliveryYesNo | 11(44%)14(56%) | 22(54.8%)25(53.3%) | 0.820 |
| >25 years | Pre-term deliveryYesNo | 05(17.5%)24(82.8%) | 16(47.1%)18(52.9%) | 0.012 |
| **Anemia**No | **Abnormal AF**YesNo | 13(38.2%)21(61.8) | 16(35.6%)29(64.4%) | 0.0530.807 |
| Yes | YesNo | 12(60%)08(40%) | 12(33.3%)24(66.7%) |
| **Obesity**No | **Abnormal AF**YesNo | 10(41.7%)14(5833%) | 19(45.2%)23(54.8%) | 0.0200.779 |
| Yes | YesNo | 15(50%)15(50%) | 09(23.1%)30(76.9%) |
| **DM**No | **Abnormal AF**YesNo | 18(51.4%)17(48.6%) | 14(34.1%)27(65.9%) | 0.8900.128 |
| Yes | YesNo | 07(36.8%)12(63.2%) | 14(35%)26(65%) |
| **Age**<25 years | **Abnormal AF**YesNo | 12(48%)13(52%) | 15(31.9%)32(68.1%) | 0.180 |
| >25 years | YesNo | 13(44.8%)16(55.2%) | 13(38.2%)13(61.8%) | 0.596 |

hemodynamic modification of the fetus, the inclination to disrupt the pregnancy prevents the death of the intrauterine fetus. Hence, the correlation between changes in Doppler and lower gestational age showed that the shorter the duration of pregnancy, the worse are the fertility results. Therefore it is comprehend that gestational age of pregnancy is challenging when interaction between changes in the Doppler and fertility outcomes are observed.

Very high number of RDS associated with preterm deliveries, Doppler navel remodeling was associated with (six times) greater risk of RDS, but this association was depleted when corrected. When adverse birth effects were tested, RDS was associated with gestational age, in addition to chronic intrauterine hypoxaemia. Hence, the increased risk of RDS in Doppler-related conditions could be due to premature pregnancies caused by the Doppler Effect rather than fetal hypoxia. Therefore, age should not be underestimated while doing analysis of the data examined in the current study after considering its significance.

The Doppler indicators found from the current study of pregnancy with a standard outcome shows consistency with results in the previous study and similar to the results reported in current study in most institutions.21 Current study also found that there was no statistically significant difference in rates when normal pregnancies compared with unusual outcomes. The obvious implementation of this is that Doppler of the uterine artery may not be good for diagnosing pregnancy with adverse effects of placental abruption, in contradictory with other studies where this goal is recommended.22 In a literal sense, our destiny may be affected by certain factors. It could be due to limited sample size that has a important impact on results, and an adequate sample size would be required to justify the findings. Three factors including, poor antenatal care services, less use of Doppler scan in the management of pregnant women and low socioeconomic status in many developing institutions are well-known features of the small sample. The alternative to improving the size of a small sample is to introduce Doppler scan as an integral part of a standard second trimester scan. This is due to the frequent use of the scan in the second trimester by many healthcare providers in antenatal patients [23]. We used a second trimester anomaly scan to examine the cervix at the same time. Apart from the factors mentioned above, another possible cause for the lack of indication of differences between normal and complicated pregnancies is related to the diversity of problematic etiologies, which is rarely considered in the design of many studies.22 This is the reason for the low sensitivity and clarity in many other studies.22

These problems reported in the current study shows similarity with other studies [22]. Surprisingly, however, high blood pressure disorders were not the most commonly occurring reason in the study as reported in previous literature.23, 22 This could be no role of local hypertension conditions the cause of placental abruption. As a result, no difference will be observed in the uterine symptoms when compared to normal pregnancy. When hypertensive disorders that usually begins late in pregnancy and are more severe then the association with other maternal disorders, including diabetes mellitus, coagulation disorders, etc., are observed to be a major factor [22]. Intrauterine growth inhibition was one of the duo's most common problems. It is hypothesized that reduction of utero-placental circulation because of inadequate trophoblastic invasion  occurring as early as 20 weeks resulting in IUGR, despite the restoration of utero-placental flow with general Doppler indications by week 22nd to 23rd when tests were performed [21].

Current research shows that premature birth is one of the most common complications. However, we did not find any differences in Doppler's indications between preterm pregnancies and long-term births. This is in contrast to other studies that have reported a correlation between premature birth and rare Doppler symptoms.22 It is possible that most of these conditions are due to medical interventions following other problems in particular, high blood pressure disorders.

The effect of maternal age and equality on birth rates was emphasized by the study results. Maternal aging shows relationship with certain adverse effects on pregnancy.24 The implication of what we note is that the results of Doppler indicators should take into account these changes specially, the age of the mother and equality, if we want to get better and the similarity of the results from different studies.

The results found in current study are relevant to clinical practice, as they have considered three key factors. First, all the procedures were performed when the body was adapting arterial changes  around 22nd - 23rd week of pregnancy.22 Second, the proximal part of the cervical vertebra where the external iliac cross.23 At this stage, the uterine artery exhibits complete obstruction of the distal utero-placental circulation provided by the spiral or arcuate arteries.22 Third, no other than trained and well-experienced healthcare worker who performs all procedures to reduce coefficients between viewer and intra-observer can be as high as 10.1% and 10.8% of PI.22 However, that lack of proper exercise routines may in some cases occur within 20 weeks, compared to 24 weeks are generally considered too late to initiate intervention in high-risk cases based on abnormal findings.21 Weeks 22 - 23 are recommended for 2 reasons. Firstly, most of those who have started to become accustomed to abnormal physical activity will continue until this time and secondly, those with abnormal late physical activity will reappear.23 Doppler's low predictive profile of uterine due to misunderstanding of etiology factor variability and economic perception includes in normal conditions. Onwards, it is recommended to do further research on methods for measuring indicators, the inclusion of biological and clinical biomarkers and the possibility of late trimester testing late. There is a need for early implementation of precautions like use of low-dose aspirin in high-risk women and the overall pregnancy effect.

Conclusion

The beneficial outcomes in obstetric and neonatal care were found when high-risk pregnancies were monitored with Doppler studies, but at each facility, the significance of Doppler in late pregnancy research is affected by the use of other well-established investigations. In clinical practice, moreover, UtA Doppler velocimetry needs to be performed in the 2nd trimester. Additionally, healthcare providers should closely monitor and advise their high-risk patients, even in isolated cases.

References

1. Wang W, Xie X, Yuan T, Wang Y, Zhao F, Zhou Z, et al. Epidemiological trends of maternal hypertensive disorders of pregnancy at the global, regional, and national levels: a population-based study. BMC Pregnancy Childbirth. 2021 May 8;21(1):364. doi: 10.1186/s12884-021-03809-2.
2. Khowaja AR, Qureshi RN, Sheikh S, Zaidi S, Salam R, Sawchuck D, et al. Community's perceptions of pre-eclampsia and eclampsia in Sindh Pakistan: a qualitative study. Reprod Health. 2016 Jun 8;13 Suppl 1(Suppl 1):36. doi: 10.1186/s12978-016-0136-x
3. Anderson UD, Olsson MG, Kristensen KH, Åkerström B, Hansson SR. Biochemical markers to predict preeclampsia. Placenta. 2012;33: S42-7
4. Bramham K, Briley AL, Seed P, Poston L, Shennan AH, Chappell LC. Adverse maternal and perinatal outcomes in women with previous preeclampsia: a prospective study. Am J Obstet Gynecol. 2011; 204:512. e1-9.
5. Ghulmiyyah L, SibaiB.Maternal mortality for preeclampsia/eclampsia. SeminPerinatol. 2012;36:56-9
6. Emanuel M, Butt S. Frequency and factors leading to recurrent pre-eclampsia. J Pak Med Assoc. 2015 Nov;65(11):1173-7
7. Bezerra Maia e Holanda Moura S, Marques Lopes L, Murthi P, da Silva Costa F. Prevention of preeclampsia. J pregnancy. 2012; 2012. doi: 10.1155/2012/435090
8. Hernández-Díaz S, Toh S, CnattingiusS.Risk of preeclampsia in first and subsequent pregnancies: prospective cohort study.BMJ. 2009;338: b2255.
9. Giles WB, Trudinger BJ, Baird PJ. Fetal umbilical artery flow velocity waveforms and placental resistance: pathological correlation. Br J Obstet Gynaecol. 1985 Jan;92(1):31-8.
10. Chen JF, Fowlkes JB, Carson PL, Rubin JM, Adler RS. Autocorrelation of integrated power Doppler signals and its application. Ultrasound Med Biol. 1996;22(8):1053-7.
11. Burns PN. Principles of Doppler and color flow. Radiol Med. 1993 May;85(5 Suppl 1):3-16.
12. Messawa M, Ma’ajeni E, Daghistani MH, Ayaz A, Farooq MU. The role of doppler ultrasound in high risk pregnancy: A comparative study. Niger Med J. 2012 Jul-Sep; 53(3):116–120.
13. Hartung J, Kalache KD, Heyna C, et al. Outcome of 60 neonates who had ARED flow prenatally compared with a matched control group of appropriate-for-gestational age preterm neonates. Ultrasound Obstet Gynecol. 2005; 25:566-72
14. Sebire NJ, Goldin RD, Regan L. Histomorphological evidence for chronic vasoconstriction of placental stem vessels in pregnancies with intrauterine growth restriction and abnormal umbilical artery Doppler velocimetry indices. J Pathol. 2001; 195:19A.
15. Papageorghiou AT, Yu CK, Bindra R, Pandis G, Nicolaides KH, et al. Multicenter screening for pre-eclampsia and fetal growth restriction by transvaginal uterine artery Doppler at 23 weeks of gestation. Ultrasound Obstet Gynecol. 2001 Nov;18(5):441–9.
16. Groom KM, North RA, Stone PR, Chan EH, et al. Patterns of Change in Uterine Artery Doppler Studies Between 20 and 24 Weeks of Gestation and Pregnancy Outcomes. Obstet Gynecol. 2009 Feb;113(2 Pt 1):332–8.
17. Hecher K, Bilardo CM, Stigter RH, et al. Monitoring of fetuses with intrauterine growth restriction: a longitudinal study. Ultrasound Obstet Gynecol. 2001;18:564-70.
18. Soothill PW, Ajayi RA, Campbell S, et al. Relationship between fetal acidemia at cordocentesis and subsequent neurodevelopment. Ultrasound Obstet Gynecol.1992; 2:80-3.
19. Zelop CM, Richardson DK, Heffner LJ. Outcomes of severely abnormal umbilical artery doppler velocimetry in structurally normal singleton fetuses. Obstet Gynecol. 1996; 87:434-8.
20. Harman CR, Baschat AA, Gembruch U. Venous Doppler in IUGR. Which vessel? Which parameter? Am J Obstet Gynecol. 2001;185:53.
21. Schreuder AM, McDonnell M, Gaffney G, et al. Outcome at school age following antenatal detection of absent or reversed end diastolic flow velocity in the umbilical artery. Arch Dis Child Fetal Neonatal Ed. 2002;86:F108-14
22. Arduini D, Rizzo G, Romanini C, Marcuso S. Uteroplacental blood flow velocity waveforms as predictors of pregnancy -induced hypertension. Eur J Obstet Gynecol Reprod Biol. 1987 Dec;26(4):335–41.
23. Peleg D, Kennedy CM, Hunter SK. Intrauterine Growth Restriction: Identification and Management. Am Fam Physician. 1998 Aug;58(2):453–60, 466-7.
24. Conde-Agudelo A, Villar J, Lindheimer M. World health Organization systematic review of screening tests for preeclampsia. Obstet Gynecol. 2005 May;105(5 Pt 1):1151–2.